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SGC – Civil Engineering Section
LMS – Soil Mechanics Laboratory
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Civil systems project
Fall Semester 2024
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Project - 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 for soil improvement. 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 technology is an essential step towards optimizing treatment strategies. Efforts of many authors have resulted in the development of models and validation with experimental results (e.g., Minto et al., 2019; Van Wijngaarden et al., 2016; Zeng et al., 2021). However, models presented in literature cannot represent all relevant settings and model validation on a scale which can be considered as representative of real problem mitigation is lacking.

Towards this objective, a modelling framework for large-scale is developed (results in terms of calcite content presented in Figure 1) but needs to be calibrated and evaluated. This project aims to calibrate the modelling framework with experimentally obtained results and to evaluate the importance of the modelling parameters used.

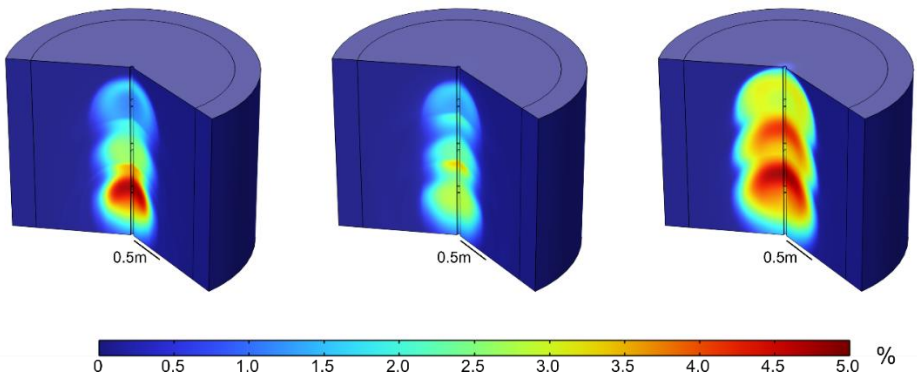

Figure 1, Modelling results (calcite content, mass percentage) showing biocemented improved zones.

References

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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
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- 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

The primary goal of this project is to perform model calibration to find the optimal modelling parameters to represent experimentally performed results. It is aimed to gain further insight into the importance of all variables and couplings.

Tasks and work to carry out

- Understand the current modelling framework and its limitations. Understand the meaning of all modelling parameters. Make an overview of all parameters and their commonly used values and constraints, based on a literature review.
- Define which experimental results to calibrate the model against. The experiments were performed in a large-scale setup; therefore, different results on the respective chemo and hydro components are available.
- Selecting a suitable model calibration method, and evaluating different options for the sensitivity analyses and their feasibility. Inspiration can be taken from Saltelli (2004) and Wojnarowicz (2024).
- Perform model calibration and conclude on the best model parameters to represent the experiments performed. Demonstrate the influence of the different model parameters on the obtained results and highlight where the model has difficulty representing the experimentally obtained results.

Deliverables

The work/topic proposed in this document can be adjusted to fit a bachelor thesis, master thesis or a semester project, according to the wishes of the student

- 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 (day and time can be discussed) 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) an idea for the next steps for the project. During these meetings, the supervisors may vary the foreseen goals of the project, if necessary.

- Report

The report will be written in English. In the document, the student will have to clearly introduce the topic, to highlight the hypotheses made, to present the considered methodology, to discuss the obtained results and to draw the related conclusions.

- **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.

- Deadlines

The tasks of the project should be accomplished from September 9th, 2024 to January 5th, 2025. The report should be submitted to the supervisors by January 24th, 2025.

Grading

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

- Implication and initiative during the semester 30%
- Technical report 50%
- Oral presentation 20%

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.

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