CALCITE – Fixation Mechanisms and Durability of Biocementation Treatment of Soils. Application to a Real Slope to Prevent Ravine Development

Summary

The durability of soil treatment using biocementation will be investigated in this project, CALCITE, by studying bacteria fixation mechanisms and calcium carbonate production under the stable insoluble form of calcite, as well as by developing durability tests for biocemented soils. Prototypes and a case study of a real slope treated against ravine development are predicted, to be monitored along time to detect ravine formation and quantify changes on calcite content due to atmospheric exposition. Accelerated tests will be performed in small scale prototypes, which results will help developing prediction tools for the long term performance of the treated slope. The team gathers expertise on soil testing and characterization, soil improvement, durability tests in construction materials and bioengineering, constitutive modelling (IST-ID) and on the development of sensing and microfluidic devices at nano-micro scale necessary to visualize crystal formation and monitor bio-chemical processes occurring during the treatment (INESC-MN). CALCITE results from project BIOSOIL (PTDC/ECI-EGC/32590/2017), focused on developing monitoring tools for soil treatment using biocementation. The equipment necessary to perform biocementation in soils and carve stone joints was developed, the team learned how to produce lyophilized bacteria aiming to store ready-to-use large quantities, and also a magnetic biosenso was developed to monitor enzyme urease produced by the bacteria. Several studies exist on using biocementation as low carbon footprint soil improvement technique, alternative to traditional solutions where binding agents such as Portland cement are used. Although most of these studies are performed in laboratory environment, some field cases are reported focusing on soil strengthening and erosion protection in dikes. Reported field cases prove that the technique is feasible at large scale and companies Soletanche-Bachy and Medusoil are investing in it. Existing studies are focused mainly on defining suitable soils and treatment protocols (bacteria type and dosage, feeding frequency and dosage), costs and environmental aspects, and also on quantifying soil improvement. Because this is a recent technique (end of XX century) and only few field cases exist, apart few studies simulating the effect of freeze-drying cycles on biocemented soils and improvement against erosion, durability is still not properly investigated. It is fundamental to increase trust on this treatment and has motivated this research, being a valuable contribution to current knowledge. Durability of the treatment will be investigated adopting three complementary strategies: (i) Investigate the environmental conditions affecting the production of calcite by the bacteria species selected, instead of other mineral forms of calcium carbonate.

Microfluidic devices will be used, allowing to visualize mineral formation and collecting fluids for analysis. (ii) Study durability in treated soils by subject the samples to wetting-drying cycles simulating climate actions. The novelty is in the study of durability of this treatment, developing adequate protocols for such analysis using standard techniques. Numerical modelling of the observations using a coupled chemo-hydro-mechanical analysis, will also be done to help predicting the amounts of calcite precipitated and dissolved. (iii) Promote a field case by applying the treatment in a real slope against ravine formation and monitor its performance during time (Figure 1). Several excavated slopes on sandy formations in Portuguese roads are candidates for the treatment. No ethical issues concerning bacteria injection in soils will rise because only a small extension will be treated, collecting all fluids. This will be the first Portuguese case-study on biocementation and will call the attention of the media and of the techno-scientific community. In addition, main practical application issues associated not only to durability and maintenance, but also homogenization, normalization procedures, ethical and contamination concerns, etc, will be discussed in an international workshop to be promoted at the end.

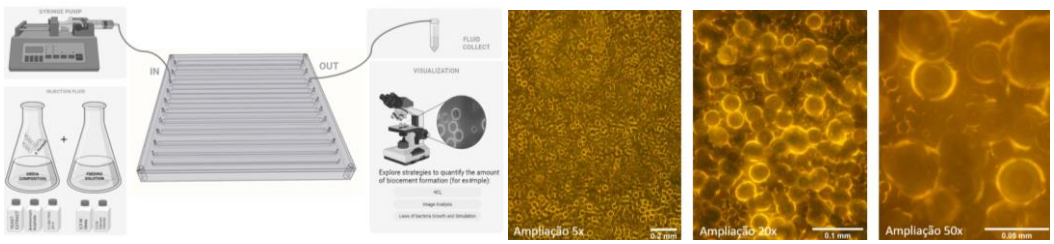

Figure 1. Scheme of the microfluidic device and preliminary results showing calcite particles.

Project Reference

PTDC/ECI-EGC/1086/2021

Leading Institution

IST-ID – Associação do Instituto Superior Técnico para a Investigação e Desenvolvimento (Portugal)

Partners

INESC-MN – INESC Microsistemas e Nanotecnologias (Portugal)

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CERIS

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Project Website

fenix.tecnico.ulisboa.pt/homepage/ist13977/projecto-calcite