CERIS : Civil Engineering Research and Innovation for Sustainability

BIOSOIL – Biological Treatment of Soils: Development of Tools to Monitor the Application and to Predict Changes on the Material's Hydro-Mechanical Properties

Summary

The use of bacteria or other biological agents for soil improvement by calcification, also called as biocementation, is a relatively recent promising technique. Attention is being focused on its practical use because, besides being able to provide the material with the required mechanical and hydraulic properties, the effects of the biological treatment mimics Nature and therefore reduces ecological footprint. Several studies have been done, mainly in laboratory environment, to: (i) understand optimum treatment conditions (definition of bacteria species and dosages, feeding composition and frequency, purge) and (ii) quantify and predict the earnings achieved for each treatment condition and type of soil. Some field cases (see for example http://www.bachysoletanche.com/SBF/sitev4_uk.nsf/sb/techniques.innovation-awards) are now emerging and prove that the technique is feasible at large scale and has commercial potential. Nevertheless, monitoring techniques for the treatment application in the field, as well as tools to predict the properties of the treated material, are required to launch biocementation into Practice.

These two needs motivate the research proposed, which can be divided into three main parts: (i) development of tools to monitor the application of the treatment along its duration; (ii) testing and characterization of the hydro-mechanical properties (HM properties) of the treated material prepared for different and realistic treatment protocols; and (iii) considering the treatment protocol followed and the expected changes in the HM properties, define relationships useful for the bio treatment of soils.

The first part consists in the development of a magneto-resistive sensor to detect urease in the purge fluid (Fig. 1). The presence of this enzyme produced by the bacteria selected (*S. Pasteurii*) indicates that the treatment is in progress. The sensors will be tested during the treatment of a sand (grading size distribution and relative density known), simulating a field application. The tests will be performed under different conditions, using a small-scale laboratory setup (Perspex box with 0.5x0.5x0.5m^3, incorporating injection and purge systems) developed for this purpose.

The second part is focused on the evaluation of the hydro-mechanical properties of the treated soils determined by standard laboratory tests (confined and triaxial compression, with measurement if the saturated permeability). The samples will be extracted from the small-scale laboratory setup, and also produced in moulds conceived specially for this purpose (Perspex cylinders with an axial feeding and purging system along the entire height of the 7cm diameter and 14cm height specimen). These tests will be complemented with electron scanning images, mercury intrusion porosimetry and chemical analysis to measure the amount of precipitated calcium carbonate (biocement), to relate the changes observed in the HM properties with the presence and geometry of the pores occluded by this mineral. The biocement will be bonding the sand grains and for this reason the HM properties of the soil change with the treatment. Predictions on the amount of biocement produced done using stoichiometric calculations will be corrected considering the amounts measured in the several tests done. The corrected calculations will be used in the definition of a bonding parameter to be incorporated in a constitutive model for bonded materials.

In the third part, data from the HM tests and the measurements made using the sensors will make possible to relate several parameters, for example: (i) amount of enzyme versus dosage of bacteria injected; (ii) amount of enzyme versus the duration of the treatment; (iii) amount of enzyme versus amount of biocement produced; These relationships are valid for the soil type studied and set of conditions adopted for the treatment (operational parameters), and for this reason at least two different grading size distributions will be tested. The information of all tests will be joined and abacus-like plots relating operational parameters with the final properties of the material will be produced, useful for designers and contactors.

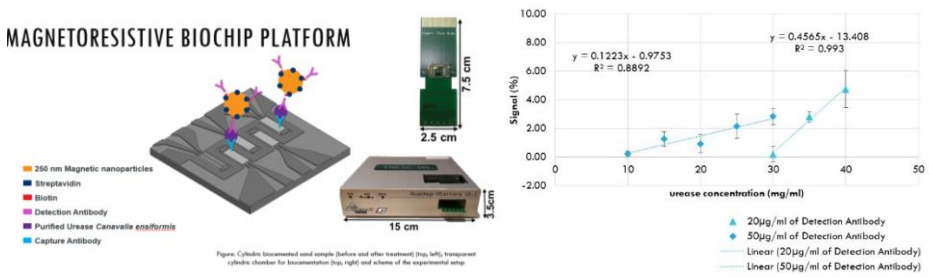

Figure 1. Overview of the biosensor and example of calibration curves.

BIOSOIL

Project Reference

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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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