FORM PER PROGETTI BANDO DOTTORATO

1. Project title

Nature-based Soil Stabilization: An Integrated Fungal-Polymer and MultiSensor Framework (FUNGI-SOIL)

2. Proposer

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4. Key words
(Max. 5 – at least 2)

Nature-based solutions; Soil stabilization; Fungal mycelium; Biopolymers; Multi-sensor monitoring; IoT; Machine learning

5. Abstract
(Max.1.500 characters with spaces)

Soil stabilization is a key technique for improving problematic soils as swelling–shrinking soil. Conventional stabilization methods based on lime are widely used due to their effectiveness; however, their high environmental impact, associated with significant CO_2 emissions, raises concerns about their long-term sustainability.
Increasing attention has been directed toward Nature-Based Solutions (NbS) as biopolymers. More recently, fungal-induced soil stabilization has emerged as a promising approach. Despite these advances, the combined use of fungal mycelium and biopolymers remains largely unexplored, particularly with respect to swelling/shrinking behaviour and field-scale application.
This research aims to develop and evaluate an integrated fungal–biopolymer stabilization approach for swelling–shrinking soils, with the objective of providing a sustainable alternative to conventional binders. The study combines laboratory experimentation, field-scale validation, and advanced monitoring techniques. Laboratory tests will investigate hydraulic and swelling/shrinking properties under varying soil types, treatment, and curing conditions. Field implementation will be carried out through a stepwise upscaling approach, supported by in situ sensors and remote sensing techniques for continuous monitoring of soil behaviour. Data integration and modelling will enable the development of predictive tools for long-term performance assessment.
The expected outcomes include improved understanding of the mechanisms governing soil stabilization using fungal mycelium, biopolymers, and their combined effects in mitigating swelling–shrinkage behaviour, a proposed framework for modifying geotechnical standards to include "living" soil additives for eco-friendly ground improvement, guidelines for the application of fungal–biopolymer stabilization techniques in different soil and environmental conditions, development of data-driven

approaches for predicting swelling/shrinking behaviour, implementation of sensor-based monitoring strategies for continuous assessment of the effects of fungi+biopolymer on soil.
Moreover, the research aims to contribute to the advancement of sustainable engineering geology by promoting low-carbon, nature-based alternatives for soil stabilization and climate change adaptation.