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Soil reinforcement at the Château Saint-Barthélemy

CASE STUDY

Country:
Switzerland

Year:
2025

Application:
Soil Reinforcement

Client & Partners:
St. Barthelemy Foundation

Execution type:
Injection

Soil type:
Silty clay

Product:
BCEM I (BioSlurry)

Project Scope:

As part of the restoration of the Château Saint-Barthélemy, a targeted ground improvement intervention was carried out along the eastern façade, based on geotechnical and heritage-related recommendations. The subsoil consists of heterogeneous fills, sandy silts, and silty clays, some exhibiting shrink–swell behavior. These swelling and cracking clays, sensitive to moisture variations, represent a potential source of instability, capable of inducing differential ground movements and contributing to cracking of historic masonry.

The objective of this first phase was to reduce hydro-mechanical heterogeneities, reinforce preferential seepage paths, and stabilize shallow foundation soils, while fully respecting the heritage character of the structure.

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Design and Intervention Layout:

The intervention covered the eastern façade and was divided into two zones based on site geometry and constraints:

- Zone 1: length ≈ 5.3 m, injection spacing 50 cm, located 50 cm from the foundation wall.
- Zone 2: length ≈ 4.7 m, injection spacing 30 cm, located 30 cm from the foundation wall.

Drilling was performed to a depth of 3 m, targeting soil horizons most sensitive to moisture variations. The injection layout was designed to ensure localized and controlled diffusion of the treatment in critical zones.

Equipment and Execution Methodology

Standard drilling and injection equipment, comparable to conventional permeation grouting systems, was used to ensure a robust and minimally intrusive execution.

- Drilling method: air drilling with mobile compressor
- Borehole diameter: ≈ 51 mm
- Drilling depth: 3 m
- Injection pressure: ~0.5 bar
- Flow rate: ~10 L/min
- Injected volume: ≈ 40 L per linear meter

Injection was carried out at very low pressure, allowing the biocementation solution to naturally follow preferential hydraulic pathways without imposing mechanical stress on the structure.

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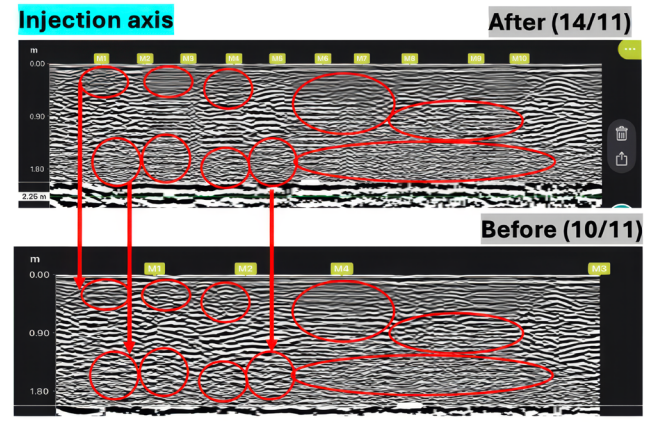
Monitoring & Performance Assessment:

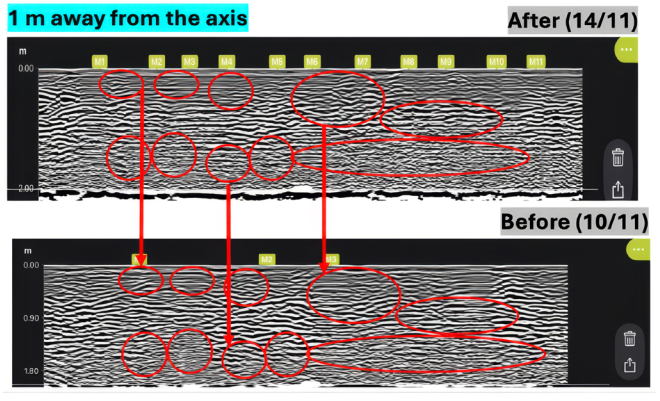
A non-destructive monitoring strategy was implemented to assess ground response before and after treatment.

- GPR monitoring using a 400 MHz antenna, covering depths of 0–3 m, suitable for detecting fine-scale heterogeneities.
- Electrical resistivity tomography (ERT) performed as a complementary investigation to characterize subsurface heterogeneity.

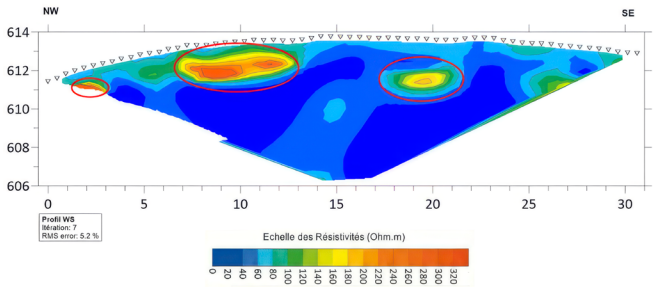
GPR surveys conducted before and after injection show a clear, localized modification of the signal in the treated zones, with smoother reflectors and reduced fine anomalies, indicating progressive homogenization of the soil structure due to biocementation.
Areas away from the injection axes (1 m) show little to no significant change, confirming a controlled injection within the target zone and no leaching of the solution despite an heterogenous ground.

The combined geophysical results confirm that the treatment preferentially targeted hydraulically heterogeneous and mechanically sensitive zones.





The ERT survey, carried out along the southern façade of the castle over a length of approximately 31 m, confirms the high degree of subsurface heterogeneity typical of historic sites and highlights the presence of preferential hydraulic pathways. These zones are also the most susceptible to fine-particle washout, shrink–swell behavior of clayey layers, and differential ground movements. The ERT results therefore provide a robust baseline for the continuation of the project, allowing future phases to rely on resistivity imaging to refine injection targeting at greater depth and to assess the spatial extent and effectiveness of biocementation beyond the shallow horizons, in direct complement to near-surface GPR monitoring.



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